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Gamification of Basic Electronics Using CRUMB Circuit Simulator on Students Behavioral Intention

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Abstract

This study explores the integration of the extended Unified Theory of Acceptance and Use of Technology (UTAUT2) in the gamification of basic electronics utilizing CRUMB Circuit Simulator on students' behavioral intention. It aims to examine the behavioral intention of the students in utilizing e-learning tools and gamification approaches. This research utilizes a mixed-method quantitative design, incorporating surveys and pilot testing of the software, incorporating surveys and pilot-testing of the software. It focuses on seven exogenous or independent variables: performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit, with behavioral intention as the endogenous or dependent variable. The study utilized SmartPLS (PLS-SEM) version 4.0 by Ringle et al., 2022. The result shows that there are only two hypotheses that have a positive influence on the behavioral intention of the students, with a path coefficient of 0.05 or below, indicating a positive relationship. Hypothesis one (H1), with a path coefficient of 0.024, performance expectancy has a positive influence on behavioral intention, signifying that, if there is an increase in performance expectancy, there is also an increase in behavioral intention. Hypothesis seven (H7) with a path coefficient of 0.000 suggests that the habitual actions and routines of students significantly shape their behavioral intentions in the academic realm. On the other hand, the correlation of all exogenous variables shows a positive influence on the learners' behavioral intention, emphasizing the significance of performance expectancy with a correlation of 0.522 and habit with a correlation of 0.720 in fostering a strong connection. In conclusion, learners perceive CRUMB Circuit Simulator as a dynamic tool for enhancing their likelihood of completing tasks assigned in each lesson. It enhances their productivity when utilizing this game, providing an interactive learning in a 3D platform.

Keywords: Behavioral Intention, Gamification, CRUMB Circuit Simulator, Extended Unified Theory of Acceptance and Use of Technology, Technology Education

1. Introduction

The evolution of education in recent years has been marked by a significant shift towards more technolgy-based learning methods. This trend has been particularly noticeable in the adoption of teaching strategies such as Gamification, which is highly beneficial, especially for Generation Z (Miranda, 2020). Educators were now paying attention to the learning behavior of Generation Z. For instance, the study of Cickovska (2022) shows that the students' behavior towards the learning process results in demotivation due to professors' teaching methods that are not compatible with the learning context of Generation Z. Instead of reacting defensively, educators were encouraged to partner with students and establish a learner-centered setting. This involves identifying suitable teaching methods and strategies, crafting educational materials, and designing tasks utilizing technology to foster interactive and engaging learning experiences. The implementation of gamification, which uses e-learning tools like Kahoot, Quizizz, Quizlet, and other applications or software is now usually employed in elementary, high school, and higher education settings. Numerous studies have been published about the implementation of gamification and game-based learning for vocational education that has been beneficial to the different levels of education, and the field that produces an article in the VET sector is the engineering field. The vocational institutions that have published most of the studies were in Asia, specifically, Thailand (Dahalan et al., 2023).

In the field of technology education, specifically in basic electronics that undergoes rapid advancements, new technologies and components are continuously introduced. Nevertheless, educational curricula often struggle to keep up with these changes. Therefore, it is crucial to identify the most suitable instructional approach to support students in basic electronics with their academic endeavors to foster and maintain their engagement. This is important because interest is a vital component in achieving high academic performance, particularly in technology education. Research indicates that the collaborative instructional approach is more successful in enhancing students' cognitive achievements in Basic Electronics than the scaffolding instructional approach (Atsumbe et al., 2018). Thus, this study will implement a collaborative approach during the pilot testing of the newly developed circuit simulator. It is worth noting that college instructors have already utilized online programs and applications, such as Electronic Workbench, to enhance their teaching in the Basic Electronics program. The most recent circuit simulator is named CRUMB Circuit Simulator, developed by Mike Bushell in 2022. The CRUMB Circuit Simulator is a user-friendly, browser-based tool that allows students to design and simulate basic electronic circuits in 3D form. Through this software, students can learn how to use electronic circuits and their components, analyze circuit behavior, and design circuits without the risk of component malfunction, ultimately avoiding additional cost for damaged elements (CRUMB Circuit Simulator, n.d.). Using this simulator, educators can simulate and demonstrate their developed circuit examples in situations or activities that are similar to those found in real life. It can help them aid their teaching by allowing students to visualize each circuit and application of each component without the physical presence of the component. Therefore, the purpose of this study is to assess learners' behavioral intention towards the gamification of basic electronics using CRUMB Circuit Simulator.

This research aims to integrate the extended Unified Theory of Acceptance and Use of Technology (UTAUT2) into the gamification of basic electronics using the CRUMB Circuit Simulator to evaluate learners' behavioral intention. It also evaluates the significant relationship between each construct towards the behavioral intention of the students in utilizing the CRUMB Circuit Simulator. Lastly, it assesses the behavioral impact of the adopted gamification e-learning tool for basic electronics utilizing the CRUMB Circuit Simulator on the behavior of the learners in the learning process. To collect and analyze data, this study will utilize a quantitative research method. Data will be collected through a survey of students to gain a comprehensive understanding of their experiences and perceptions after the pilot testing of the software or game. The results of this research have the potential to reveal the present behavioral intentions of the students in adopting new e-learning tools, which then help educators in designing more effective and engaging technology-based learning tools in the field of electronics education.

2. Literature review

2.1 The Extended Unified Theory of Acceptance and Use of Technology (UTAUT2)

This generation is known for its extensive use of e-learning resources to enhance and accelerate its academic journey (Hernandez-De-Menendez et al., 2020). The integration of mobile technologies has proven advantageous in the teaching and learning process, as technology has brought about a rapid transformation in the methods of education. To assess the adoption, preparedness, and acceptance of academic faculties in Chinese higher education, an extensive study was conducted using the extended Unified Theory of Acceptance and Use of Technology (UTAUT2) model. A comprehensive quantitative survey was conducted on a large scale to examine the factors influencing the behavioral intentions and usage of mobile technologies across six institutions representing various levels, including national, provincial, and vocational. Data obtained from the quantitative study were analyzed using Statistical Package for Social Sciences (SPSS) 24.0 and SmartPLS-SEM 3.0. The findings indicated that there are external factors such as social influence, facilitating conditions, and price value that had an impact on the intention and actual usage of mobile technologies in instructional practice among academics. On the other hand, there are potential internal factors, including performance expectancy, effort expectancy, hedonic motivation, and habit, that can also influence the use of mobile technologies. Interestingly, hedonic motivation emerged as a significant predictor for both academics' intentions to use mobile technologies and their actual usage. Nevertheless, while facilitating conditions, including some aspects of technological knowledge, the present investigation defined technological competence as, rather than being incorporated into facilitating conditions, one highly crucial factor, and with the utilization of UTAUT2, mobile technologies are claimed to be beneficial in assisting academics in delivering engaging and entertaining lectures (Hu et al., 2020).

2.2 Gamification

The application of gamification in the teaching and learning process is to boost each student’s motivation to learn. It involves teaching methods that make use of the game’s mechanics and the application of game elements like a point system, level system, badge system, or leaderboard system. Although gamification offers lots of benefits, such as increasing students’ motivation and engagement, increasing students’ learning outcomes, and influencing the learning process, there still are limitations. Learning that occurs through intrinsic motivation is better than learning that occurs for the sake of obtaining rewards, which is extrinsic motivation. Although gamification offers lots of benefits, such as increasing students’ motivation and engagement, increasing students’ learning outcomes, and influencing the learning process, there still are limitations. From a technical standpoint, learning that occurs through intrinsic motivation is better than learning that occurs for the sake of obtaining rewards as the latter facilitates negative psychological effects when the game becomes the dominant factor. The game becomes the dominant factor, which can have negative psychological effects. Although gamification in education is often regarded as successful and effective, it is important to acknowledge that it can also encounter failures. Therefore, as an educator, implementing gamification in teaching requires careful design and should be accompanied by assessing students' progress toward achieving the learning objectives. Additionally, educators themselves need to possess a willingness to learn and apply technology, as proficiency in ICT skills becomes essential (Fitria, 2022). Other institutions have incorporated gamification into their teaching practices through diverse E-learning tools, yet some schools and educators have not yet ventured into the adoption of these methods. This may be attributed to the lack of well-defined definitions and guidelines that offer comprehensive assistance in the creation and assessment of gamification approaches. By thoroughly examining and elaborating on the depiction of gamification elements using a taxonomy approach, it becomes possible to identify the benefits and drawbacks associated with them. This analysis aids in determining and providing educators with valuable guidance on the most effective methods for utilizing these elements appropriately (Toda, 2019).

2.3 CRUMB Circuit Simulator

The purpose of developing the CRUMB Circuit Simulator was not to disregard nor replace the traditional workbench. Instead, it was created to coexist with it, serving as a tool that preserves the workbench's functionality. By using the simulator, you can test and verify your ideas in a virtual environment without taking any risks. Once you achieve the desired results in the simulation, you can then confidently apply your findings in real-life situations without incurring unnecessary expenses on components that may not be useful. Moreover, it also aids individuals studying electronics by building their understanding of fundamental principles such as interactivity, and the replication of existing models that have been proven effective in real-world scenarios, which is valuable for instructional purposes (Ditchy, 2022).

3. Methodology of the Study

In this study, a quantitative research design was employed, utilizing a survey technique and pilot testing of the CRUMB Circuit Simulator to gather information. The participants will engage in collaborative activities prepared by the researcher, allowing for the evaluation of the relationship or connection between the exogenous or independent variables and the respondents' behavioral intention. This will be assessed while the participants interact with the Circuit Simulator and experience the application of gamification in the basic electronics course.

During the pilot testing of the CRUMB Circuit Simulator, the participants will be grouped into teams with 3-4 members, and given a set of activities to be accomplished. The researcher will give feedback on each team's performance after they have completed the game. Following its conclusion, a survey questionnaire will be distributed to the participants who have completed the activity to assess their overall experience and determine the impact and effectiveness of the students' behavioral intention toward the e-learning gamification tool in facilitating learning and enhancing their experience in the learning process.

The gathered data will be analyzed using the SmartPLS version 4.0 (PLS-SEM) software that is commonly used in the UTAUT and UTAUT2 models. SmartPLS is a widely recognized tool for conducting partial least squares structural equation modeling (PLS-SEM), a statistical approach employed to examine connections between latent (unobservable) constructs and observable variables (Sarstedt et al., 2019).

3.1 Respondents of the Study

The participants of this study will be students who have completed the Basic Electronics course and students who are currently enrolled. In this manner, they already possess an understanding of the activities they will engage in. Using the A-prior sample size calculator for the structural equation model by Daniel Soper, the minimum required number of respondents in this study is 135.

Table 1: Total Respondents

Year	Course	Number of Students
2nd	BS-ECE	19
3rd	BS-IA	31
3rd	BS-IAM	32
3rd	BET-ESET	18
3rd	BET-ELET	24
4th	BS-IA	21
4th	BS-IAM	30
4th	BET-ELET	18
		TOTAL: 193

3.2 Research Instruments

The researcher will adopt the UTAUT2 questionnaire for elderly acceptance from Benjamin S. Siow to assess students' behavior towards the gamification activities and e-learning tool being used. The instrument employed the Likert scale to assess the participant's level of experience with the gamification tool, utilizing a scale from 1 (strongly disagree) to 5 (strongly agree). The questionnaire comprises eight categories namely: Performance Expectancy (four items), followed by Effort Expectancy (four items), Social Influence (three items), Facilitating Conditions (four items), Hedonistic Motivation (three items), Price Value (three items), Habit (four items), and Behavioral Intention (three items). The students will rate a total of 28 items that identify their experience with the activities they participated using the CRUMB Circuit Simulator.

3.3 Data Gathering and Analysis

The researchers will gather data and collect information from past studies, research papers, action papers, and books that are relevant to the present study. The pilot testing of the e-learning tool will be conducted, afterwards, the questionnaire will be administered to the students with permission from the dean’s office. After each procedure, the researchers will retrieve and converge all the data for analysis and interpretation. The UTAUT2 model was measured using SmartPLS version 4.0 by Ringle et al., 2022.

3.3.1 Pilot Testing Procedure

Before the data analysis, the simulator was utilized by the students for them to experience how an e-learning tool with the application of gamification should be implemented. Respondents were grouped, each consisting of 3-4 members. A collaborative approach was used since this approach is more effective in enhancing the students' learning of Basic Electronics (Atsumbe et al., 2018).

- To evaluate the impact of the tool on the behavioral intention of the students towards the simulator, the researcher provided ten (10) accounts of the CRUMB Circuit Simulator from Steam and 10 laptops for them to use.
- A total of ten (10) basic introductions to electronics activities were prepared, with the objectives of identifying the functions of each electronic component, demonstrating the given circuits, and appreciating the importance of each component in the circuit and the gamification of the Circuit Simulator. Each group will perform every activity. During this stage, the researcher employs the constructivist approach, facilitating student learning through practical experiences, existing knowledge application, and the acquisition of new information in a collaborative type of learning, enabling them to learn from one another ("What Is Constructivism?", 2022, https://www.interaction-design.org/literature/topics/gamification). In this phase, as students will be able to simulate the following circuit, they will have hands-on experience with how the CRUMB Circuit Simulator works. They can then reflect or evaluate the function of the gamified Circuit Simulator if it helps them achieve future basic electronics activities.
- Upon utilizing the CRUMB Circuit Simulator, students will collaboratively experience the concepts of a gamified learning theory. These activities aim to foster self-determination in the acquisition of knowledge and skills in basic electronics, influenced by collaborative efforts and direct action. When students feel that they have the skills needed for success, they are more likely to take actions that will help them achieve their goals. This psychological framework explains how being self-determined impacts the behavioral intention of the students in performing the task given with the use of the Circuit Simulator (Cherry, 2022).
- After the completion of the activities, a survey questionnaire will be given to assess the students' experiences with the e-learning tool. The adopted questionnaire from Benjamin S. Siow will determine the potential integration of the extended Unified Theory of Acceptance and Use of Technology (UTAUT2), assessing the significant relationship between exogenous or independent variables and behavioral intention.

4. Results and Discussions

This section provides an analysis and interpretation of the data collected, which was tabulated, computed, and examined. The primary objective of this interpretation is to assess the extended Unified Theory of Acceptance and Use of Technology and its applicability in incorporating gamification into higher education through the CRUMB Circuit Simulator, and to assess the influence of the adopted e-learning tool on learners' behavioral intention in the utilization of technology in the gamification of electronic instruction.

4.1 Diagram of Significant Relationship between Exogenous and Endogenous Variable (after Bootstrapping)

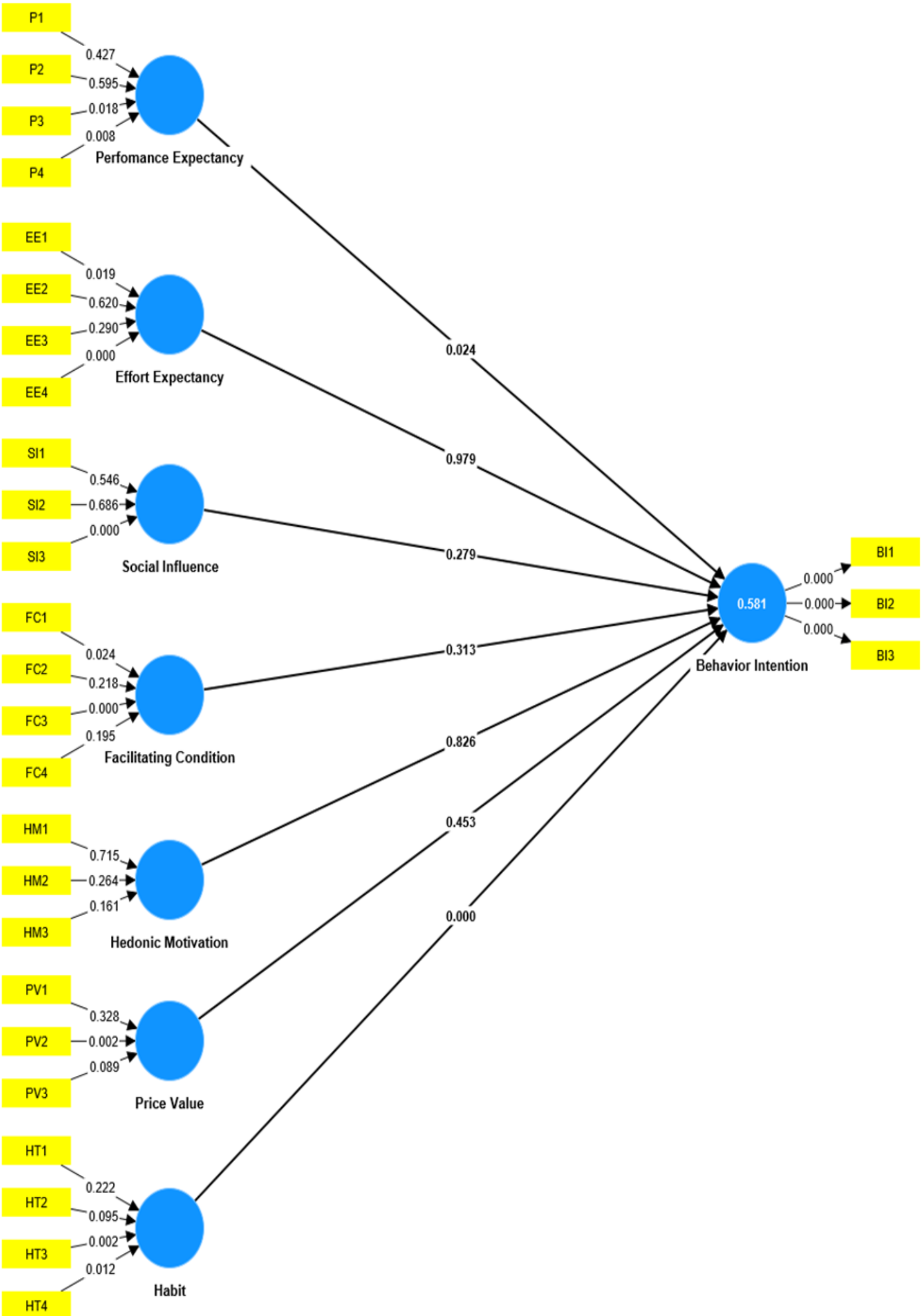

Figure 1: The Interpretation of the Significant Relationship between Exogenous Variables and Endogenous Variables after Bootstrapping

Nonparametric bootstrapping-based 95% confidence intervals were computed and used to determine the significance of estimates. This resulted in the corresponding p-values of a path coefficient. The significance of a path coefficient is usually determined by p-value, and if the p-value is less than a chosen significance level (commonly 0.05 or below), the path coefficient is considered statistically significant. Therefore, there is enough statistical evidence to suggest that the relationship between the variables is not due to random chance (Frost, 2023).

Figure 1 displays informative p-value results. As observed, the only constructs that display significant results are Performance Expectancy and Habit, since their corresponding values are 0.024 and 0.000 respectively, both below the 0.05 significance level. This suggests that students' expectations of their performance and habits significantly influences the behavioral intention in utilizing the CRUMB Circuit Simulator software.

However, the Effort Expectancy, Social Influence, Facilitating Condition, Hedonic Motivation, and Price Value do not significantly influence the behavioral intention since its p-values are more than the 0.05 set significance level. This suggests that factors such as the perceived ease of software use, positive opinions and attitudes of others, availability of supportive resources, positive feelings or enjoyment while using the software, and perceived cost-effectiveness do not strongly influence students' behavioral intention to utilize the software.

4.3 Correlation between Variables

The following results were presented and discussed accordingly:

Table 2. Interpretation of the Correlation between Exogenous and Endogenous Variables

Correlations								
	Behavioral Intention	**Effort Expectancy**	**Facilitating Condition**	**Habit**	**Hedonic Motivation**	**Performance Expectancy**	**Price Value**	**Social Influence**
Behavioral Intention	1.000							
Effort Expectancy	0.418	1.000						
Facilitating Condition	0.490	0.428	1.000					
Habit	0.720	0.433	0.540	1.000				
Hedonic Motivation	0.388	0.319	0.280	0.475	1.000			
Performance Expectancy	0.522	0.564	0.400	0.447	0.406	1.000		

Price Value	0.545	0.277	0.416	0.643	0.444	0.427	1.000	
Social Influence	0.522	0.490	0.444	0.513	0.368	0.598	0.534	1.000

Table 2 presents the correlation coefficients between the exogenous variable and endogenous variables. Each coefficient represents the level of monotonic association between the two variables.

Behavioral Intention and Hedonic Motivation

The correlation coefficient regarding Behavioral Intention concerning Hedonic Motivation is 0.388 suggesting a weak relationship. Hedonic motivation, as defined by the UTAUT2 model, refers to the positive feelings or enjoyment derived from using a particular technology or system (Venkatesh et al., 2012). According to Sitar-Taut (2021), attitude plays a significant influence on behavioral intentions, hence, the greater the level of enjoyment and encouragement the higher the levels of acceptance. In the context of using the CRUMB Circuit Simulator, one factor that might decrease the relationship between hedonic motivation and behavioral intention is the students' perspective of enjoyment and entertainment when using the software. Another possibility is the students' differences; for instance, some students may not find joy in using the CRUMB Circuit Simulator due to personal preferences, learning styles, or other individual characteristics (Li & Xue, 2023).

Behavioral Intention and Effort Expectancy

The correlation coefficient of Behavioral Intention to Effort Expectancy is 0.418, suggesting a weak association. Consequently, as the effort expectancy of a student increases, there is a slight tendency for their behavioral intention to also increase. Effort expectancy, as defined in the UTAUT model, refers to the perceived ease or difficulty of a task. It is the degree of ease associated with using certain systems (Venkatesh et al., 2003). In the study by Pan & Gao published in 2021 titled "Determinants of the behavioral intention to use a mobile nursing application by nurses in China", they found that the less effort nurses need to invest in using a mobile app, the more likely they intend to use it. Likewise, in the context of using CRUMB Circuit Simulator, the less effort they need to invest in the software, the more likely they are to accept it. Inversely, one factor that might cause the weak relationship between the students' behavioral intention and effort expectancy is that they find the software difficult to navigate, which could be due to the activity or the context in which it is used.

Behavioral Intention and Facilitating Condition

The correlation coefficient between Behavioral Intention and Facilitating Condition is 0.490, suggesting a weak association. This indicates that students' behavioral intentions to use the CRUMB Circuit Simulator software tend to increase slightly as the Facilitating Condition increases. Facilitating condition, as defined in the UTAUT model, refers to the environmental factors that make it easier for a person to engage (Venkatesh et al., 2003), these factors could include the availability of the technology and the presence of supportive resources (Fitrianie et al., 2021). In the context of using the CRUMB Circuit Simulator software, the less effort the students need to invest in the software, the more likely they are to accept it, that is, if the CRUMB Circuit Simulator is readily available and easy to use, they are more likely to intend to use it. Therefore, the availability of the software could potentially weaken the relationship between the behavioral intentions of the students concerning facilitating conditions.

Behavioral Intention and Social Influence

The correlation coefficient of Behavioral Intention concerning Social Influence is 0.522, implying a moderate association. Therefore, as this construct increases, there is a corresponding moderate increase in the behavioral intention of the students to utilize the CRUMB Circuit Simulator. Social Influence is the extent to which a person perceives that significant others endorse the idea that he or she should adopt the new system (Venkatesh et al., 2003). The Theory of Planned Behavior (TPB) is a well-recognized psychological theory positing that an individual's behavioral intention, such as motivation or decision to perform a certain behavior, is influenced by three factors: (1) their attitude towards the behavior, (2) their subjective norms, and (3) their perceived behavioral control (Brookes, 2023). Social influence comes into play in the form of subjective norms, which are the individual's belief about whether people who are important to them think they should or should not perform the behavior (Centers for Disease Control and Prevention, n.d). In connection to the CRUMB Circuit Simulator, social influence is the perception of the user to social pressures to use the software. If the opinions and attitudes of others are positive towards using the software, the students are more likely to utilize it.

Behavioral Intention and Performance Expectancy

The correlation coefficient of Behavioral Intention concerning Performance Expectancy has a similar value of 0.522, implying a moderate association. Thus, as this construct increases, there is a corresponding moderate increase in the behavioral intention of the students to utilize the CRUMB Circuit Simulator. Performance expectancy refers to the belief that one will be able to perform a task effectively. It is the degree of confidence that a user has in their ability to use a particular system or technology (Venkatesh et al., 2003). In the study of Anthony, along his collaborators in 2021, they found that performance expectancy was positively associated with lectures' behavioral intention toward using a specific technology. Similarly, in the context of using CRUMB Circuit Simulator software, if the students believe that they will be able to perform a task effectively, they are more likely to intend to use it.

Behavioral Intention and Price Value

The correlation coefficient of Behavioral Intention concerning Price Value is 0.545, suggesting a moderate positive relationship. As a result, as the consideration of Price Value increases, there is a corresponding moderate increase in the students' behavioral intention in the utilization of the CRUMB Circuit Simulator software. In economic theory, Price Value refers to the perceived worth or cost-effectiveness of a product or service. It is the amount of money a consumer is willing to pay for a product or service (Adel et al., 2022). In the UTAUT2 model, the incorporation of Price Value aims to tackle the affordability concerns associated with technology usage in consumer environments. The empirical results obtained from their investigation into Price Value carry implications for the pricing strategies adopted by vendors of consumer IT applications (Ventatesh et al., 2012). Regarding the utilization of the CRUMB Circuit Simulator, if students view the simulator as valuable—believing it will improve their learning experience, impart valuable skills, or enhance their ability to perform tasks—they are more inclined to express an intention to use it.

Behavioral Intention and Habit

The Behavioral Intention concerning Habit has the highest correlation coefficient with a value of 0.720, indicating a high association between these variables. This suggests that as the consideration of habit increases, there is a corresponding high increase in the students' behavioral intention to utilize the CRUMB Circuit Simulator software. The amount to which people tend to perform behaviors automatically as a result of learning has been termed a habit (Limayem et al., 2007). Research suggests a potential correlation between behavioral intention and habit. For example, individuals who have developed a habitual pattern of using a particular system or service are more inclined to possess a heightened Behavioral Intention to continue using it. This is attributed to the conditioning effect of the habit, increasing the likelihood of user engagement in the behavior (Gardner et al., 2020). If students have a practice of utilizing particular systems or services, they are more likely to have a high Behavioral Intention to utilize the CRUMB Circuit Simulator.

4.3 Path Coefficient

In the Structural Equation Model (SEM), variables are connected in paths, and each path's associated coefficient represent the strength and direction of the relationship. Positive path coefficients indicate a positive relationship, hence, an increase in one variable leads to an increase in another. Conversely, negative coefficients suggest a negative relationship, where an increase in one variable corresponds to a decrease in another. Path coefficients quantify the direct effects between variables, indicating the degree to which a change in one variable influences another (Structural equation modeling – MIT, n.d.).

Table 3. The Interpretation of Path Coefficients of the Hypothesis.

Path Coefficients						
	Original sample (O)	**Sample mean (M)**	**Standard deviation (STDEV)**	**T statistics (|O/STDEV|)**	**P values**	**Interpretation**
Effort Expectancy -> Behavioral Intention	0.002	0.024	0.073	0.026	0.979	Not significant: Do not Reject H_o
Facilitating Condition -> Behavioral Intention	0.075	0.084	0.074	1.008	0.313	Not significant: Do not Reject H_o
Habit -> Behavioral Intention	**0.520**	**0.499**	**0.088**	**5.934**	**0.000**	**Significant: Reject H_o**

Hedonic Motivation -> Behavioral Intention	**-0.015**	**0.008**	**0.066**	**0.220**	**0.826**	**Not significant: Do not Reject H_o**
Performance Expectancy -> Behavioral Intention	**0.191**	**0.185**	**0.085**	**2.252**	**0.024**	**Significant: Reject H_o**
Price Value -> Behavioral Intention	0.061	0.079	0.081	0.750	0.453	Not significant: Do not Reject H_o
Social Influence -> Behavioral Intention	0.081	0.070	0.074	1.083	0.279	Not significant: Do not Reject H_o

Table 3 presents results that support the structural diagram outlined earlier. As mentioned previously, of the seven exogenous or independent variables, only Performance Expectancy and Habit show a significant relationship with behavioral intention, indicated by p-values of 0.024 and 0.000, respectively. Additionally, path coefficients of 0.191 and 0.520, respectively, reveal a robust positive direction in the relationship concerning the behavioral intention of students when utilizing the CRUMB circuit simulator software.

Hypotheses Testing

Null Hypothesis (Ho): Performance expectancy does not positively influence students' behavioral intention on the gamification of the e-learning tool.

Alternative Hypothesis (H1): Performance expectancy has a positive influence on students' behavioral intention on the gamification of the e-learning tool.

Interpretation:

Performance expectancy has a p-value of 0.024 (< 0.05) and a path coefficient of 0.191. This implies that the null hypothesis is rejected. Thus, it has a positive influence on the students' behavioral intention on the gamification e-learning tool. Most students believed that using the game or Circuit Simulator helps them accomplish their tasks quickly and increases their productivity. Students' behavioral intentions to utilize Information and Communication Technology (ICT) for learning at MUCG are positively influenced by Performance Expectancy. Essentially, the students' expectations of their ability to perform using ICT for learning directly affect their intentions to use this technology (Attuquayefio and Addo, 2014). Several studies also obtained the same result, and that performance expectancy is one of the constructs that have positive effects or influence on behavioral intention (Ameri et al., 2019, Chao, 2019, Nikolopoulou et al., 2020, and Pan & Gao, 2021).

Null Hypothesis (Ho): Effort expectancy does not positively influence students' behavioral intention on the gamification of the e-learning tool.

Alternative Hypothesis (H2): Effort expectancy has a positive influence on students' behavioral intention on the gamification of the e-learning tool.

Interpretation:
Effort expectancy has a p-value of 0.979 (> 0.05), thereby leading to the acceptance of the null hypothesis. This also implies that there is no significant relationship between Effort Expectancy and Behavioral Intention. The path coefficient of 0.002 indicates a weak direct relationship to Behavioral Intention, suggesting that changes in effort expectancy are associated with very small changes in Behavioral Intention. In simple terms, based on the collected data, there is not enough evidence to conclude that Effort Expectancy has a significant impact on the behavioral intention of the students to use the CRUMB Circuit Simulator software.
Null Hypothesis (Ho): Social influence does not positively influence students' behavioral intention on the gamification of the e-learning tool.
Alternative Hypothesis (H3): Social influence has a positive influence on students' behavioral intention on the gamification of the e-learning tool.

Interpretation:
Social influence has a p-value of 0.279 (> 0.05) meaning to accept the null hypothesis. In essence, these findings indicate that there is no significant relationship between Social influence and Behavioral Intention. A path coefficient of 0.081 indicates a weak direct relationship to Behavioral Intention, indicating that changes in the Social Influence are associated with minor shifts in Behavioral Intention. In summary, based on the collected data, the results do not provide adequate evidence to assert that a substantial impact of Social Influence on Behavioral Intention.
Null Hypothesis (Ho): The facilitating condition does not positively influence students' behavioral intention on the gamification of the e-learning tool.
Alternative Hypothesis (H4): The facilitating condition has a positive influence on students' behavioral intention on the gamification of the e-learning tool.

Interpretation:
The facilitating condition has a p-value of 0.313(> 0.05), leading to the acceptance of the null hypothesis, further implying that there is no significant relationship between the Facilitating Condition and Behavioral Intention. A path coefficient of 0.075 indicates a weak direct relationship to Behavioral Intention, which implies that alterations in the Facilitating Condition are linked to minor changes in Behavioral Intention. In summary, based on the gathered data, there is not enough evidence to affirm a substantial impact of the Facilitating Condition on students' Behavioral Intention in utilizing the CRUMB Circuit Simulator software. Consequently, while the environment or conditions that make it easier to use the software do exist, they do not significantly influence the students' intention to use it.
Null Hypothesis (Ho): Hedonic motivation does not positively influence students' behavioral intention on the gamification of the e-learning tool.
Alternative Hypothesis (H5): Hedonic motivation has a positive influence on students' behavioral intention on the gamification of the e-learning tool.

Interpretation:

The Hedonic Motivation has a p-value of 0.826(> 0.05) leading to the acceptance of the null hypothesis, which implies that there is no significant relationship between the Hedonic Motivation and Behavioral Intention. A path coefficient of -0.015 indicates a weak negative relationship to Behavioral Intention, indicating that changes in the hedonic motivation are associated with minor changes in Behavioral Intention. In summary, based on the gathered data, there is not enough evidence to affirm the significant impact of Hedonic Motivation on students' Behavioral Intention in utilizing the CRUMB Circuit Simulator software. This suggests that enjoyment or pleasure derived from using the software does not significantly influence the students' intention to use it.

Null Hypothesis (Ho): Price value does not positively influence students' behavioral intention on the gamification of the e-learning tool.

Alternative Hypothesis (H6): Price value has a positive influence on students' behavioral intention on the gamification of the e-learning tool.

Interpretation:

The Price Value has a p-value of 0.453(> 0.05) leading to the acceptance of the null hypothesis, implying that there is no significant relationship between the Price Value and Behavioral Intention. A path coefficient of 0.061 indicates a weak negative relationship to Behavioral Intention, indicating that changes in the facilitating condition are linked with minor changes in Behavioral Intention. In summary, based on the data collected, there is not enough evidence to conclude the significant impact of Price Value on students' behavioral intention in the utilization of the CRUMB Circuit Simulator software. This means that while the cost or value of using the software could exist, it does not significantly influence the students' intention to use it.

Null Hypothesis (Ho): Habit does not positively influence students' behavioral intention on the gamification of the e-learning tool.

Alternative Hypothesis (H7): Habit has a positive influence on students' behavioral intention on the gamification of the e-learning tool.

Interpretation:

Habit has a p-value of 0.000 (< 0.05) and a path coefficient of 0.520. This implies that the null hypothesis is rejected. As a result, it has a positive influence on the students' behavioral intention on the gamification of the e-learning tool. Habit has the strongest significant relationship with Behavioral Intention. This is attributed to students becoming accustomed to using the gamified tool, integrating it into their learning process to accomplish assigned activities. Habit is a key determinant, influencing both the direct and indirect effects on an individual's behavioral intention in utilizing technology. In computer and internet adoption, the research demonstrates that both direct and indirect impacts of habit on the elderly's internet usage intention and their behavioral technology usage are both statistically significant (Yap et al., 2022). Several studies also found that habit is one of the factors that has a favorable effect or influence on behavioral intention (Ameri et al., 2019, Chao, 2019, Eneizan et al., 2019, Hu et al., 2020, Nikolopoulou et al., 2020).

4.4 Significance of Latent Variable to Endogenous Construct

Table 4. Interpretation of the Significance of Latent Variable to Endogenous Construct.

	f-square	Significance of Latent Variable to Endogenous Construct
Effort Expectancy -> Behavioral Intention	0.000	Insignificant
Facilitating Condition -> Behavioral Intention	0.009	Moderate
Habit -> Behavioral Intention	0.286	Significant
Hedonic Motivation -> Behavioral Intention	0.000	Insignificant
Performance Expectancy -> Behavioral Intention	0.045	Significant
Price Value -> Behavioral Intention	0.004	Moderate
Social Influence -> Behavioral Intention	0.008	Moderate

Table 4 displays additional results that support the finding that both Habit and Performance Expectancy play a meaningful role in influencing Behavioral Intention. Looking at the relationship between Performance Expectancy and Behavioral Intention, the f-square value of 0.045 indicates a small effect size. This suggests that Performance Expectancy contributes a small portion of the total variance in Behavioral Intention. Despite the statistical significance of the relationship between Performance Expectancy and Behavioral Intention, the small effect size implies that the practical significance or meaningfulness of this relationship might be limited in real-world scenarios. This highlights the importance of considering additional factors that exert a more substantial influence on shaping individuals' intentions.

On the other hand, Habit indicates a moderate effect size with an f-square of 0.286. This suggests that Habit explains a substantial proportion of the variance in Behavioral Intention. It indicates a meaningful impact, falling between a small and large effect size. The moderate effect size implies that Habit is a significant predictor of Behavioral Intention. Changes in Habit are associated with noticeable variations in Behavioral Intention, providing evidence for the relevance of habitual behaviors in predicting intentions. The strong influence of Habit on Behavioral Intention could be due to habitual behaviors becoming automatic over time, reducing the need for conscious decision-making (Alotumi, 2022). As a result, previous experiences with the CRUMB Circuit Simulator software could have a more significant impact on students' Behavioral Intention to use the software than their Performance Expectancy.

The f-square effect size is categorized as small if it is greater than or equal to 0.02, medium if it is greater than or equal to 0.15, and large if it is greater than or equal to 0.35 (ResearchWithFawad, 2022) — the following variables exhibit f-square values below the categorized effect size:

The result indicate that Effort Expectancy and Hedonic Motivation have a very small effect size (f-square=0.000), an indicative of an extremely small effect size. This suggests that, in the context of this study, Effort Expectancy and Hedonic Motivation make negligible contributions to the variability observed in Behavioral Intention. Consequently, Effort Expectancy is deemed insignificant in predicting Behavioral Intention. Moreover, the Facilitating Condition, with an f-square of 0.009, demonstrates a modest contribution to the variance in Behavioral Intention. The small effect size indicates that the Facilitating Condition serves as a relatively weak predictor of Behavioral Intention within the model. Additionally, Price Value and Social Influence exhibit f-square values of 0.004 and 0.008, respectively, falling below the smallest categorized effect size (≥ 0.02). This indicates that their contributions to explaining the variability in Behavioral Intention are not statistically significant.

In summary, the f-square values provide insights into the relative strength of each variable's impact on Behavioral Intention, with Effort Expectancy, Hedonic Motivation, Facilitating Condition, Price Value, and Social Influence demonstrating varying degrees of influence, as interpreted through their effect sizes.

5. Findings

The evaluation results among 193 students reveal a noticeable effect on students' behavior, indicating that the implemented e-learning tool, CRUMB Circuit Simulator, positively impacts the students' behavioral response, active participation, and accomplishment of tasks in the learning process. While all exogenous variables positively influence behavioral intention, the variables demonstrating the most robust positive relationships with Behavioral Intention are Performance Expectancy and Habit. Moreover, the study sheds light on the user's Behavioral Intention of utilizing technology, providing an understanding of how learners interact with technological tools in gamification instructional settings. In conclusion, the research highlights the potential benefits and effectiveness of integrating extended Unified Theory of Acceptance and Use of Technology (UTAUT2) principles in assessing the factors that influence students' Behavioral Intention to the newly developed e-learning tool and the gamification strategies in the field of basic electronics education. With the implementation of the theory, the observed positive influence on learners' behavior, which are the Habit and Performance Expectancy, highlights the importance of these methods in improving the overall learning experience. This approach creates a supportive and interactive learning environment, motivating students to actively engage in the learning process and acquire the necessary knowledge and skills in every given task. This aligns with the findings of hypothesis testing, indicating that performance expectancy is one of the variables contributing positively to students' Behavioral Intention to the utilization of the e-learning tool. As Habit emerges as one of the most influential variables positively affecting students' Behavioral Intention when using the game, it suggests that if learners become accustomed to or master the e-learning tool, it will become a routine for them to incorporate the game into their lesson activities or tasks. Performance Expectancy and Habit are positively significant to Behavioral Intention, as indicated by the path coefficient results. On the other hand, as indicated by the correlation between the exogenous and endogenous variables, all exogenous variables contribute to influencing students' behavioral intention in utilizing the newly developed e-learning tool. It implies that, while other variables may have lesser impact on the students' Behavioral Intention to use a specific e-learning tool such as the CRUMB Circuit Simulator, we cannot overlook their influence because the effect of these factors might change over time.

6. Recommendations

Based on the objectives and findings of the study titled "Integration of Extended Unified Theory of Acceptance and Use of Technology in the Gamification of Basic Electronics Using CRUMB Circuit Simulator," the following recommendations are proposed:

1. To enhance the utilization of the newly developed circuit simulator, the specific college department should offer thorough training sessions for both educators and students, focusing on the effective utilization of the CRUMB Circuit Simulator and its gamification elements. Such training will enable users to fully leverage the integrated technology. Additionally, customize the gamification elements within the CRUMB Circuit Simulator to align with the specific needs and preferences of the target audience. This customization can elevate the influence on learners' Behavioral Intention of using the game or e-learning tool and give better support to the learning objectives.

2. To utilize the CRUMB Circuit Simulator for long-term investigation and implement a system for continuous monitoring and evaluation of the gamification learning environment. Regular assessments can help identify areas for improvement and ensure that the integration of technology aligns with their educational goals.
3. To explore opportunities to expand the subject coverage of the CRUMB Circuit Simulator, which can enhance the versatility of the gamification learning experience.
4. To develop strategies to address technical accessibility issues, ensuring that all students have equal opportunities to engage with the gamification learning platform.
5. To consider granting access to devices or establishing computer laboratories for departments that offer basic electronics courses.
6. To collaborate with educational institutions to integrate the gamification learning approach into the formal curriculum in higher education. To work closely with educators to seamlessly incorporate the CRUMB Circuit Simulator into existing courses. Regular updates and maintenance of both the CRUMB Circuit Simulator and the gamification elements. This ensures that the technology remains current, reliable, and aligned with evolving educational needs.

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